

**SUPPORT FOR AMENDMENTS**

The specification is amended to correct grammar only. Claims 1–5 are canceled; Claims 6–17 are newly added. The correspondence between the claims is listed below:

- Claims 1 & 4 → Claim 6;
- Claim 2 → Claim 7; and
- Claims 3 & 5 → Claim 12.

In other words, Claims 1 and 4 are combined to result in new Claim 6 and Claims 3 and 5 are combined to result in new Claim 12. Support for the remaining new claims can be found in the specification, listed as follows:

- Claims 8 & 13: page 5, lines 22–24 and page 6, lines 17–19;
- Claims 9, 10, 14, & 15: page 6, lines 21–25 and page 4, lines 16–18;
- Claims 16 & 17: page 1, lines 21–22; and
- Claim 11: page 10, line 11.

New matter has not been added.

Claims 6–17 are pending.

**REMARKS/ARGUMENTS**

On the outset, Applicants thank the Examiner for indicating that Claims 4 and 5 are free of the prior art.

The rejection of Claim 1 (now Claim 6) under 35 U.S.C. § 102(a) or (e), or alternatively under 35 U.S.C. § 103(a), in view of U.S. Patent 7,288,496 (Kobatyashi et al.) is obviated by amendment. Present Claim 6 is the result of incorporating the limitations of now-canceled Claim 4 into now-canceled Claim 1. Applicants submit that present Claim 6 (and Claims dependent thereon) is patentable over Kobatyashi et al. for the same reasons now-canceled Claim 4 was not rejected in view of this reference.

Accordingly, this rejection should be withdrawn.

The rejection of Claim 3 (now Claim 12) under 35 U.S.C. § 102(b) or alternatively under 35 U.S.C. § 103(a) in view of Japanese document 2001-097779 (Yasushi et al.) is respectfully traversed. The Aluminum Nitride compositions of this reference contain *at least* 3 wt% of  $\text{Y}_2\text{O}_3$ .<sup>1</sup> Conversely, the Aluminum Nitride sintered products of the present invention contain *at most* 2 wt% of  $\text{Y}_2\text{O}_3$ .<sup>2</sup> Therefore, the Aluminum Nitride compositions of Yasushi et al. do not anticipate the presently claimed Aluminum Nitride sintered products. Furthermore, the Examiner did not reject now-canceled Claim 5 in view of this reference. The limitations of now-canceled Claim 5 are in new Claim 12. Therefore, Claim 12 is non-obvious in view of this reference for the same reasons now-canceled Claim 5 is non-obvious in view of this reference.

Accordingly, the rejection should be withdrawn.

The rejection of Claims 1–3 (now 6, 7, and 12, respectively) under 35 U.S.C. § 102(b) or alternatively under 35 U.S.C. § 103(a) in view of U.S. Patent 5,320,990 (Guiton et al.) is, in part obviated by amendment, and respectfully traversed. First, new Claim 6 is the result of incorporating the limitations of now-canceled Claim 4 into now-canceled Claim 1. Applicants submit that new Claim 6 (and Claims dependent thereon) is patentable over Guiton et al. for the same reasons now-canceled Claim 4 was not rejected in view of this reference.

Second, new Claim 12 is the result of incorporating the limitations of now-canceled Claim 5 into now-canceled Claim 3. The Examiner stated on page 4 of the Office Action that now-canceled Claim 5 is excluded from this rejection because Guiton et al. teach 2 wt% or greater of yttria. As a result, new Claim 12 is neither anticipated by nor obvious in view of this reference for the same reason now-canceled Claim 5 was excluded from the rejection.

Accordingly, this rejection should be withdrawn.

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<sup>1</sup> See Tables 1 and 2 on pages 5 and 6, respectively, of Yasushi et al.; a copy of machine translation is provided

<sup>2</sup> See Table 1 on page 26 of present specification

Applicants note that this reference discloses a broad range of 0.05 to 10 wt% for the sintering aid (e.g. Y<sub>2</sub>O<sub>3</sub>), relative to total mass of composition (col. 3: 60-66). The preferred range of sintering aid appears to be 2–3 wt% (examples in cols. 5 & 6); however, the preferred range of Y<sub>2</sub>O<sub>3</sub> in the present application is 0.14–1.5 wt% (present Claims 6 and 12). Applicants refer to the phone conversation with Examiner Group on July 18, 2008 where this issue was discussed. The Examiner agreed that the present application shows criticality and that the present claims are neither anticipated nor non-obvious in view of this reference.

Applicants contend that the application is now in condition for allowance. Early notification of such action is earnestly solicited.

Respectfully submitted,

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**DETAILED DESCRIPTION**

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**[Detailed Description of the Invention]**

[0001]

[Field of the Invention]This invention relates to the circuit board using the aluminum nitride substrate and the substrate which are used for a semiconductor device etc.

[0002]

[Description of the Prior Art]A power device is interlocked with progress of the power electronics which is the main application field, and has been playing the important role of promotion in wide range fields, such as industry, public welfare, and a car.

[0003]Power electronics has accomplished remarkable development in an industrial robot, an NC machine tool, the switching-power-supply field, etc. by making the needs of energy saving in recent years and laborsaving into a background. Furthermore, it is going to accomplish development also in the field familiar to the life of an electromobile, home automation, etc. by making the amenity of a life, and the flow of the needs of the outstanding environment nature into a background.

[0004]The power device supporting these made a thyristor, a bipolar transistor, etc. main, as for the branch exception, was set to power metal-oxide semiconductor field effect transistor, IGBT, IPM, power IC, etc., and has developed.

[0005]As a substrate applied to a power device, a ceramics board or a metal base substrate is applied. As a ceramics board, oxide stock ceramics, such as alumina ( $\text{aluminum}_2\text{O}_3$ ), have mainly been used.

However, high power-ization of a power device progresses and non-oxide ceramics which has higher thermal conductivity, such as aluminum nitride (AIN) and silicon nitride ( $\text{Si}_3\text{N}_4$ ), is applied in recent years.

[0006]When a ceramics board is applied, generally special art, such as a direct conjugation method and an active metal conjugation method, is used on the ceramics board as a technique to which a metallic circuit board is joined. A conjugation method generates the eutectic compound (eutectic crystal melt) of the ingredient of a metallic circuit board, and a ceramics board ingredient with heating directly, and both members are joined by using this eutectic compound as a bonding agent. For example, when an aluminum oxide (alumina:  $\text{aluminum}_2\text{O}_3$ ) is applied as a ceramics board and a copper (Cu) circuit board is applied as a metallic circuit board. The copper direct conjugation method (DBC:DirectBonding Copper) using the reaction of oxygen (O) in a copper circuit board (Cu) and oxygen (O) in a ceramics board ( $\text{aluminum}_2\text{O}_3$ ) is used.

[0007]According to this DBC process, it has high heat dissipation nature and high electric insulation, and the outstanding soldering nature, bonding nature, and copper adhesive strength are shown, and since a coefficient of thermal expansion is also equal to ceramics, a large-sized silicon pellet can be directly mounted to this substrate.

[0008]However, since oxygen (O) does not exist in a ceramics board (AIN) as a ceramics board when non-oxide ceramics, such as aluminum nitride (AIN), is applied, a copper circuit board and an aluminum nitride substrate (AIN) are directly unjoinable. For this reason, after oxidizing an aluminum nitride substrate and forming an oxide ( $\text{aluminum}_2\text{O}_3$ ) in an aluminum nitride substrate face, the method of joining an aluminum nitride substrate and a copper circuit board directly is used.

[0009]

[Problem(s) to be Solved by the Invention]However, in the circuit board using alumimium nitride aiming at the conventional object for power modules. According to the surface state of the oxide film on an

aluminum nitride substrate, the adhesion strength of an aluminum nitride substrate and a copper (Cu) circuit board became low, and a defect, like Cu blisters or Cu separates further occurred, and it had problems, such as causing yield lowering. In spite of having manufactured the aluminum nitride substrate in the same manufacturing process especially, the variation in the bonding strength at the time of forming a circuit board had occurred.

[0010]The purpose of this invention is as follows.

It is made in order to solve such a problem, and the adhesion strength of an aluminum nitride substrate and the metallic circuit joined on this substrate is raised, and raise joining reliability.

Provide the circuit board using the aluminum nitride substrate and the substrate which raised the yield.

[0011]

[Means for Solving the Problem]Namely, a result of having repeated examination and an examination in order that invention-in-this-application persons might solve the above-mentioned problem, By specifying quantity of YAG ( $\text{aluminum}_5\text{Y}_3\text{O}_{12}$ ) and YAL ( $\text{AlYO}_3$ ) which are the liquid phase components which exist in an aluminum nitride substrate, and YAM ( $\text{aluminum}_2\text{Y}_4\text{O}_9$ ), It found out that bonding strength and a yield of a copper circuit board and an aluminum nitride substrate were improvable.

[0012]When aluminum nitride (AlN) is used as a substrate, since combination of aluminum nitride particles is liquid phase combination, the liquid phase exists in mesh shape between each aluminum nitride particle. In a process of forming an oxide in an aluminum nitride substrate face, a presentation and quantity of the liquid phase which exist in this mesh shape accelerate oxidation, or become a factor which delays oxidation on the contrary. Compared with aluminum nitride, reactivity with an organic matter a liquid phase component of this mesh shape Since it is far early, React to carbide by which it was generated during oxidation or after oxidation by disassembly of organic matters, such as a binder by which it was generated during oxidation, and a solvent, or it reacts to an impurity of aluminum nitride substrate wash water, Invention-in-this-application persons found out reducing the junction nature of an aluminum nitride (AlN) board and a copper (Cu) circuit board.

[0013]When there were few liquid phase components of YAG and YAL, dispersion in oxidation quantity became intense, and on the contrary, when there were too many liquid phase components of YAG, YAL, and YAM among invention-in-this-application persons, they found out that the junction nature of an aluminum nitride substrate and a copper circuit board fell under the influence of an impurity.

[0014]For this reason, while improving the adhesion of a copper (Cu) circuit board and an aluminum nitride (AlN) board and raising bonding strength by specifying a liquid phase component range according to thermal conductivity of an aluminum nitride substrate, knowledge that an improvement of a yield could be aimed at was acquired. That is, conventionally, since variation arose in the bonding strength when a circuit board of what was able to be produced easily is joined, an aluminum nitride substrate with high thermal conductivity did not have an enough yield. When the cause is pursued, in order to obtain sufficient bonding strength according to each thermal conductivity, it finds out that a predetermined liquid phase component is required.

[0015]This invention is completed based on the above-mentioned knowledge. Namely, the aluminum nitride substrate according to claim 1, In an aluminum nitride substrate in which the liquid phase which consists of aluminum nitride (AlN) and contains an ingredient more than a kind among YAG, YAL, or YAM exists, When said liquid phase component sets the peak maximum height of aluminum nitride by X-ray photoelectron spectroscopy to 100, a peak height of YAG is characterized by a peak height of 15 or less and YAM of a peak height of 20 or less and YAL being six or less.

[0016]A range of thermal conductivity of an aluminum nitride (AlN) board of the invention according to claim 2 is 175 or less W/m·K exceeding 100, And when a liquid phase component sets the peak maximum height of aluminum nitride by X-ray photoelectron spectroscopy to 100, peak heights of YAG are 8-15, and the aluminum nitride substrate according to claim 1, wherein a peak height of 2-14, and YAM of a peak height of YAL is four or less.

[0017]A range of thermal conductivity of an aluminum nitride (AlN) board of the invention according to claim 3 is 100 or less W/m·K, And when a liquid phase component sets the peak maximum height of aluminum nitride by X-ray photoelectron spectroscopy to 100, it is the aluminum nitride substrate according to claim 1, wherein peak heights of YAG are 10-20.

[0018]The invention according to claim 4 is the aluminum nitride substrate according to claim 3 characterized by not detecting a peak of the liquid phase of YAL and YAM by X-ray photoelectron spectroscopy.

[0019]The invention according to claim 5 is a range in which thermal conductivity of an aluminum nitride (AIN) board exceeds 175 W/m-K. And when a liquid phase component sets the peak maximum height of aluminum nitride by X-ray photoelectron spectroscopy to 100, peak heights of YAL are 8-15, and the aluminum nitride substrate according to claim 1, wherein peak heights of YAM are 2-6.

[0020]The invention according to claim 6 is the aluminum nitride substrate according to claim 5 characterized by not detecting a peak of the liquid phase of YAG by X-ray photoelectron spectroscopy.

[0021]In the circuit board which it has, the invention according to claim 7 a metallic circuit board joined to a substrate which consists of aluminum nitride (AIN) said aluminum nitride substrate, It is an aluminum nitride substrate given in either of claim 1, 2, 3, or 5, and is the circuit board using an aluminum nitride substrate by which a copper (Cu) circuit board was joined with a copper direct conjugation method on this aluminum nitride substrate.

[0022]In the circuit board provided with a metallic circuit board joined to a substrate with which the invention according to claim 8 consists of aluminum nitride (AIN), Said aluminum nitride substrate is an aluminum nitride substrate given in either of claim 1, 2, 3, or 5, and it is the circuit board using an aluminum nitride substrate by which a copper (Cu) circuit board was joined with an active metal conjugation method on this aluminum nitride substrate.

[0023]

[Embodiment of the Invention]Hereafter, the embodiment of this invention is described using drawing 1 and Table 1, and Table 2.

[0024]In the 1st embodiment (drawing 1, Table 1) book embodiment, the addition and sintering condition of the sintering aid were changed, and the aluminum nitride (AIN) board into which thermal conductivity and a liquid phase component were changed was produced. Then, the tensile strength of each circuit board obtained by joining Cu circuit board on an AIN board, and considering it as the circuit board using a copper direct conjugation method (DBC process) was investigated.

[0025]The circuit board is produced by the procedure as shown below.

[0026]The sintering aid was added and the raw material mixture was obtained in the end of the precursor powder of AIN. As aluminum<sub>2</sub>O<sub>3</sub> and Y<sub>2</sub>O<sub>3</sub> are shown in Table 1 as a sintering aid, to the end of AIN precursor powder sample No.1 to sample No.3, as opposed to the end of AIN precursor powder -- aluminum<sub>2</sub>O<sub>3</sub> -- 1 - 2wt% and Y<sub>2</sub>O<sub>3</sub> -- 3 - 3.5wt% -- it added. moreover -- sample No.4 to sample No.10 receives in the end of AIN precursor powder -- Y<sub>2</sub>O<sub>3</sub> -- 5wt% -- it added. in addition -- since the aluminum nitride substrate of this invention is not limited to such a composition range and specified quantity formation of each liquid phase component should just be carried out -- for example, Y<sub>2</sub>O<sub>3</sub> -- 13wt% -- less than 5wt% addition is preferably possible, and it is selectable suitably also about other ingredients.

[0027]Next, after adding a binder and a solvent to the raw material mixtures from sample No.1 to sample No.10, it formed in 0.8-mm-thick sheet shape with the doctor blade method. Then, it sintered. Sample No.1 to sample No.3 performed sintering in the temperature requirement from 1755 \*\* to 1775 \*\* for 4 hours, and sample No.4 to sample No.10 performed sintering in the temperature requirement from 1775 \*\* to 1795 \*\* for 5 hours.

[0028]The sheet was cut to the division of the size of 50 mm long and 25 mm wide after sintering. The boron nitride (BN) which is an underlay powder has been arranged to the cut sheet surface, and it degreased at the temperature of 500 \*\*. The AIN substrate face was defecated after degreasing and the AIN board with which the liquid phase component was distributed over the AIN substrate face part was obtained.

[0029]The thermal conductivity of each AIN board from sample No.1 to sample No.10 obtained and the quantitative analysis of the element were carried out. The result is shown in Table 1. The element quantitative analysis of the AIN board irradiated each AIN board with the characteristic X ray of Mg as preuve, and performed it by measuring the kinetic energy of the photoelectron generated according to a photoelectric effect. That is, X-ray photoelectron spectroscopy (XPS:X-ray photoelectron spectroscopy) was applied. Cu was used for the tube voltage of 40 kV, tube current of 100 mA, the travel of 0.030 degree, and a target as a measuring condition. Although the aluminum nitride substrate of the non-polishing condition after sintering was used in this example, it is substantially satisfactory even if it uses the aluminum nitride sintered compact after polishing work. The crystal orientation in particular to measure is not pinpointed, either, and it is substantially satisfactory even if it measures in which direction.

[0030]Here, the peak height by the X-ray photoelectron spectroscopy of this invention is explained. If the surface of an aluminum nitride substrate is analyzed by X-ray photoelectron spectroscopy, each peak as shown in drawing 2 will be detected. At drawing 2, the peak of YAG showed the peak of AlN, and O seal, and the peak of YAL showed – seal for \* seal. Although four peaks of AlN have come out, they set the height (peak maximum height) of the largest peak in this to 100. Although the several peak has come out also about YAG and YAL, let the respectively largest peak in this be a peak height of each ingredient. Usually, as long as 2 theta analyzes the range of 10–50, although a maximum peak is formed in a place predetermined [ according to each ingredient ], when it laps with the peak of aluminum nitride and is hard to distinguish for example, each ingredient is good also as height and may convert the large peak to the 2nd by the publicly known conversion method. The ratio of such a peak height is specified by this invention. When a peak is not detected, the state a noise and where it cannot distinguish as \*\* seal of drawing 2 showed shall be shown.

[0031]

[Table 1]

試料No.	焼結助剤添加量(wt%)		熱伝導率 (W/m·K)	液相成分(AlN100に対する割合)			接合方法	ピール強度(kg/cm)
	Y <sub>2</sub> O <sub>3</sub>	Al <sub>2</sub> O <sub>3</sub>		YAG	YAL	YAM		
1	3	1	80	12	0	0	DBC法	6~8
2	3.5	2	75	25	0	0	DBC法	3~5
3	3	-	95	8	0	0	DBC法	4~6
4	5	-	165	10.5	11	0	DBC法	6.5~7.8
5	5	-	170	9	3	3	DBC法	7.2~8.5
6	5	-	160	6	18	0	DBC法	3~5.5
7	5	-	165	4	17	6	DBC法	4~5
8	5	-	210	0	12	5	DBC法	6~8.5
9	5	-	190	0	19	1	DBC法	4~5.2
10	5	-	205	0	12	9	DBC法	3~5

[0032]As shown in Table 1, from sample No.1, to sample No.3, thermal conductivity was 100 or less W/m·K, and although the liquid phase peak of YAG was detected, the liquid phase peak of YAL and YAM was not detected. From sample No.4, to sample No.7, thermal conductivity is a range below 175W/m and K exceeding 100, and the liquid phase peak of YAM was not detected about sample No.4 and sample No.6. From sample No.8, to sample No.10, thermal conductivity is a range exceeding 175 W/m·K, and the liquid phase peak of YAG was not detected.

[0033]Next, as shown in Table 1, each AlN board from sample No.1 to sample No.10 which has a different liquid phase component according to each thermal conductivity is introduced into the heating furnace in an air atmosphere. It heated at the temperature of 1300 \*\* for 12 hours, and the 2-micrometer-thick oxide layer (aluminum<sub>2</sub>O<sub>3</sub> coat) was formed in the AlN board all surface.

[0034]Next, the Cu foil joined to an AlN board was prepared.

[0035]Cu foil consists of tough pitch electrolytic copper containing 350 ppm of oxygen, and thickness is 0.15 mm. Where this Cu foil is laid on a hot plate, it heated for 30 seconds at the temperature of 300 \*\*, and scaling processing was performed, and the Cu foil in which the scaling layer was formed was obtained.

[0036]Thus, while carrying out contact arrangement of the obtained Cu foil at the surface side of an AlN board, contact arrangement was carried out by having made 0.13-mm-thick Cu foil into the backing material at the back side of an AlN board, and it was considered as the layered product. And it inserted in the heating furnace which adjusted this layered product to a nitrogen gas atmosphere, and was set as the temperature of 1070 \*\*, and the circuit board which joined Cu circuit board to the upper and lower sides of the AlN board directly was obtained with heating for 3 minutes.

[0037]Drawing 1 is a figure showing the section structure of the circuit board obtained by the copper direct conjugation method (DBC process).

[0038]As shown in drawing 1, as for the circuit board 1, the aluminum oxide layer (alumina: aluminum<sub>2</sub>O<sub>3</sub>) 3 is formed in the peripheral face of the AlN board 2. And it is on the aluminum oxide layer 3, and the copper (Cu) circuit board 4 is joined to the surface and the rear face of the AlN board

2.

[0039]Thus, about the circuit boards 1 from sample No.1 to sample No.10 obtained, the vertical 90-degree tensile strength of the copper circuit board 4 was investigated. It is shown in Table 1 by making the result into peel strength (kg/m).

[0040]As shown in Table 1, peel strength is 6 or more kg/cm, and each of sample No.1, No.4, No.5, and No.8 was able to obtain the circuit board 1 with high bonding strength of the AlN board 2 and the Cu circuit board 4. On the other hand, each of peel strength of sample No.2, No.3, No.6, No.7, No.9, and No.10 is less than 6 kg/cm, and sufficient bonding strength was not obtained.

[0041]The effect which the bonding strength of the aluminum oxide layer ( $\text{Al}_2\text{O}_3$ ) 3 and the copper circuit board 4 in which the circuit board 1 using the AlN board 2 applied in this embodiment was formed on the AlN board 2 surface enhances by liquid phase components, such as YAG, YAL, and YAM, is acquired. Since wettability with the copper circuit board 4 improves by a liquid phase component, the unsealed field of the AlN board 2 and the copper circuit board 4 can be decreased, and the bonding strength of the AlN board 2 and the copper circuit board 4 can be raised. namely, the aluminum oxide layer 3 of the AlN board 2 surface -- usually -- porous (porosity) one -- it is generated in the state, and when it observes on a crystal size level, the portion which the aluminum oxide layer 3 does not contact to the copper circuit board 4 has arisen. Then, by adjusting the liquid phase component of YAG, YAL, and YAM like this embodiment, it can fill up with a liquid phase component to the porous part of the aluminum oxide layer 3 effectively, and the unsealed part of the AlN board 2 and the copper circuit board 4 can be markedly alike, can decrease, and the bonding strength of both the members 2 and 4 can be raised substantially.

[0042]Therefore, where the thermal conductivity of the AlN board 2 and its thermal conductivity are maintained according to this embodiment, Improvement in the bonding strength of the AlN board 2 and the copper circuit board 4 can be aimed at, thereby, the copper circuit board 4 can exfoliate by a thermal excursion, it can blister, or poor generating of the AlN board 2 of a crack etc. can be prevented. For this reason, while being able to mass-produce a semiconductor device by a high manufacturing yield by applying the circuit board of this embodiment, it becomes possible to provide the semiconductor device which raised endurance and reliability.

[0043]In the 2nd embodiment (Table 2) book embodiment, the circuit board using an aluminum nitride substrate was produced by active metal solder.

[0044]The circuit board is produced by the procedure as shown below. The AlN board applied what was produced by the same method as a 1st embodiment. Therefore, the AlN boards from sample No.1 to sample No.10 shown in Table 1 of a 1st embodiment were used as the AlN boards from sample No.11 to sample No.20 of this embodiment. The thermal conductivity and liquid phase components of an AlN board from sample No.11 to sample No.20 are shown in Table 2.

[0045]

[Table 2]

試料No.	焼結助剤添加量(wt%)		熱伝導率 (W/m·K)	液相成分(AlN100に対する割合)			接合方法	ピール強度(kg/cm)
	$\text{Y}_2\text{O}_3$	$\text{Al}_2\text{O}_3$		YAG	YAL	YAM		
11	3	1	80	12	0	0	活性金属法	15~16
12	3.5	2	75	25	0	0	活性金属法	14~16
13	3	—	95	8	0	0	活性金属法	14~18
14	5	—	165	10.5	11	0	活性金属法	18~19
15	5	—	170	9	3	3	活性金属法	18~20
16	5	—	160	6	18	0	活性金属法	13.5~15.5
17	5	—	165	4	17	6	活性金属法	14~17
18	5	—	210	0	12	5	活性金属法	16~20
19	5	—	190	0	18	1	活性金属法	14~18
20	5	—	205	0	12	9	活性金属法	13~17

[0046]Next, pattern printing of the paste which mixed a binder and solvents, such as an organic compound, was carried out to metal powder [ activity / Ag / Ti, Cu, ] on each AlN board from sample No.11 to No.20 shown in Table 2. And Cu foil with a thickness of 0.15 mm which is from oxygen free copper with little oxygen on the surface side of each AlN board has been arranged. On the other hand, after having arranged 0.13-mm-thick Cu foil to the rear-face side of each AlN board, heating junction

was carried out for 5 minutes at the temperature of 680 \*\* among the inert atmosphere. This obtained the circuit board which joined the copper circuit board to the AlN board by active metal solder.

[0047]About the circuit boards from sample No.11 to sample No.20 obtained, the vertical 90-degree tensile strength of Cu was investigated. It is shown in Table 2 by making the result into peel strength (kg/m).

[0048]As shown in Table 2, peel strength is 15 or more kg/cm, and each of sample No.14, No.15, and No.18 was able to obtain the circuit board with high bonding strength of an AlN board and Cu circuit board.

[0049]According to this embodiment, even if it is a case where active metal solder is applied, the peel strength of 15 or more kg/cm is obtained, and the bonding strength of an AlN board and a copper circuit board can be raised. In active metal solder, although it becomes a high cost as compared with the DBC process of a 1st embodiment in order to apply expensive metal powder, such as Ti, Cu, and Ag, since welding temperature is low as compared with a DBC process, active metal solder has an advantage of being able to reduce the stress generated in an AlN board.

[0050]

[Effect of the Invention]As explained above, according to the circuit board using the aluminum nitride substrate and the substrate concerning this invention, the bonding strength of an aluminum nitride substrate and a metallic circuit board can be raised by adjusting the liquid phase component and the amount of liquid phase which exist in an aluminum nitride substrate. By controlling a liquid phase component especially according to the thermal conductivity of an aluminum nitride substrate, the circuit board with little variation in bonding strength with a metallic circuit board can be produced, and the improvement of the yield can be aimed at.

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**CLAIMS**

[Claim(s)]

[Claim 1]In an aluminum nitride substrate in which the liquid phase which consists of aluminum nitride (AIN) and contains an ingredient more than a kind among YAG, YAL, or YAM exists, An aluminum nitride substrate which is characterized by a peak height of 15 or less and YAM of a peak height of 20 or less and YAL being six or less as for a peak height of YAG when said liquid phase component sets the peak maximum height of aluminum nitride by X-ray photoelectron spectroscopy to 100.

[Claim 2]A range of thermal conductivity of an aluminum nitride (AIN) board is 175 or less W/m-K exceeding 100, And the aluminum nitride substrate according to claim 1 which is characterized by a peak height of 2-14, and YAM of a peak height of 8-15, and YAL being four or less as for a peak height of YAG when a liquid phase component sets the peak maximum height of aluminum nitride by X-ray photoelectron spectroscopy to 100.

[Claim 3]A range of thermal conductivity of an aluminum nitride (AIN) board is 100 or less W/m-K, And the aluminum nitride substrate according to claim 1 characterized by peak heights of YAG being 10-20 when a liquid phase component sets the peak maximum height of aluminum nitride by X-ray photoelectron spectroscopy to 100.

[Claim 4]The aluminum nitride substrate according to claim 3 characterized by not detecting a peak of the liquid phase of YAL and YAM by X-ray photoelectron spectroscopy.

[Claim 5]Thermal conductivity of an aluminum nitride (AIN) board is a range exceeding 175 W/m-K, And the aluminum nitride substrate according to claim 1 characterized by peak heights of 8-15, and YAM of a peak height of YAL being 2-6 when a liquid phase component sets the peak maximum height of aluminum nitride by X-ray photoelectron spectroscopy to 100.

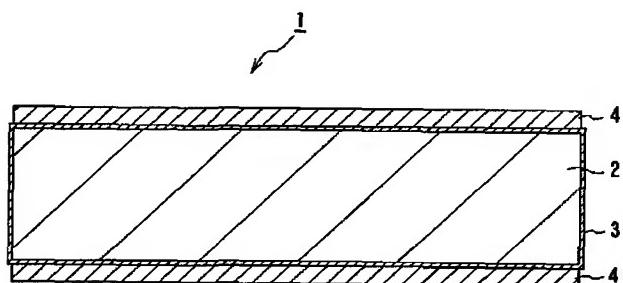
[Claim 6]The aluminum nitride substrate according to claim 5 characterized by not detecting a peak of the liquid phase of YAG by X-ray photoelectron spectroscopy.

[Claim 7]In the circuit board which it has, a metallic circuit board joined to a substrate which consists of aluminum nitride (AIN) said aluminum nitride substrate, The circuit board using an aluminum nitride substrate which is an aluminum nitride substrate given in either of claim 1, 2, 3, or 5 and by which a copper (Cu) circuit board was joined with a copper direct conjugation method on this aluminum nitride substrate.

[Claim 8]In the circuit board provided with a metallic circuit board joined to a substrate which consists of aluminum nitride (AIN), The circuit board using an aluminum nitride substrate by which said aluminum nitride substrate is an aluminum nitride substrate given in either of claim 1, 2, 3, or 5, and a copper (Cu) circuit board was joined with an active metal conjugation method on this aluminum nitride substrate.

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[Translation done.]

Drawing selection Representative drawing 

- 1 回路基板  
2 塗化アルミニウム(AlN)基板  
3 酸化アルミニウム(Al<sub>2</sub>O<sub>3</sub>)層  
4 銅(Cu)回路板

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[Translation done.]